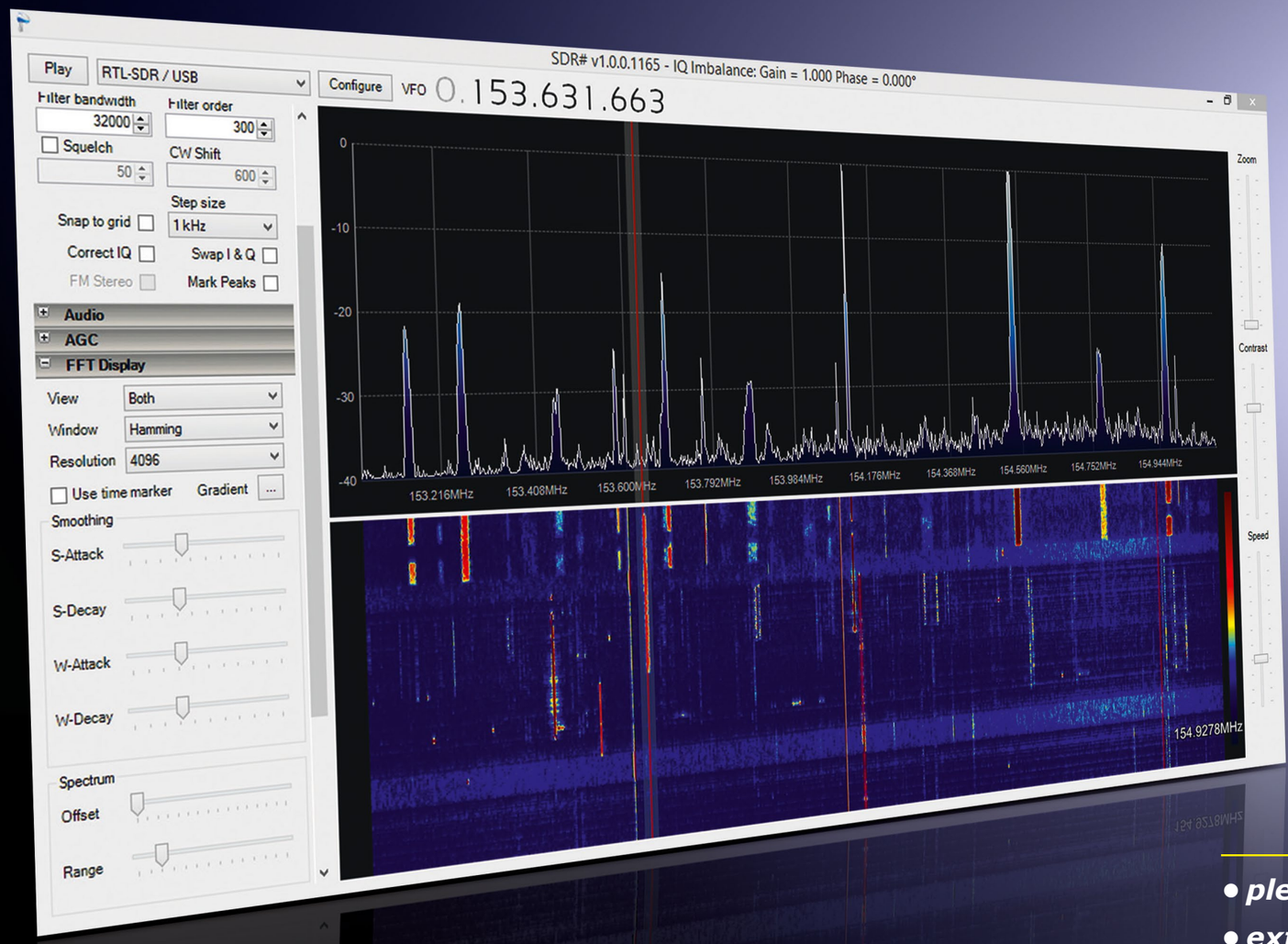
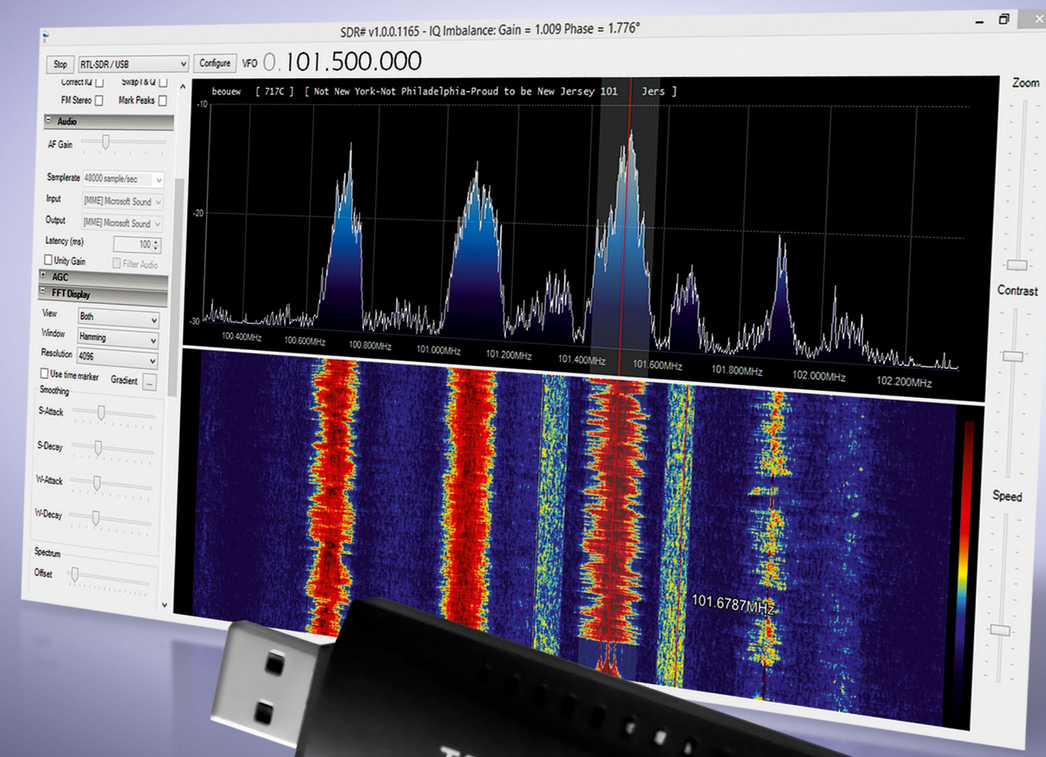
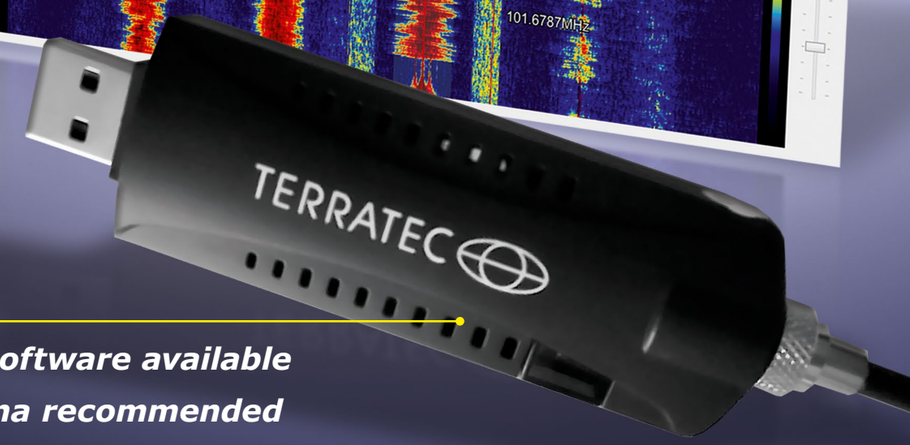
Software Defined Radio with a DVB-T Dongle







- *plenty of free software available*
- *external antenna recommended*
- *do not use the software which comes with the dongle*
- *add-ons widen the spectrum to include AM and SW*

Use of Digital Video Broadcast-Terrestrial (DVB-T) Dongles as Broadband Receivers

by Mario Filippi, N2HUN

DVB-T and DVB-T2 are the terrestrial digital tv standards in many parts of the world. If you own a laptop or a desktop computer, then a very economic way to receive those tv signals is the use of those thumb-sized dongles. They run off the USB port, are powered by five volts, and most of them receive from the low end of the VHF band all up to the top of the UHF band.

In other parts of the world the terrestrial digital tv standards are ISDB-Tb (most of South America) and ATSC (North America). So in those parts of the world such a DVB-T dongle is of no use, right? To the contrary! Amazingly, these dongles support listening modes of interest to the hobbyist everywhere in the world, such as AM (Amplitude Modulation), FM (Frequency Modulation, both narrow and wideband), USB (Upper Sideband), LSB (Lower Sideband), CW (Continuous Wave, a.k.a. Morse code) and even DRM (Digital Radio Mondiale). Add to this the feature of viewing a two MHz wide portion of spectrum (using companion software) you'll have a veritable receiving powerhouse that opens up a world of listening pleasure.

Prices of those DVB-T dongles range from $12.00 to $90.00 USD depending on the chipset. By chipset I'm referring to the two most important electronic components; the tuner and demodulator, which govern not only the price but the receive frequency range. For example, DVB-T dongles with the Elonics 4000 tuner covering 64 – 2300 MHz cost upwards of $90.00 USD while those based on the R820T chipset cover 25 - 1700 MHz and are more reasonably priced around $16.00 USD.

1. Typical R820T DVB-T dongle covering 25 - ~1700 MHz.
2. Terratec TStick+ dongle covering 64 - ~2400 MHz with Elonics 4000 tuner.

Some points to ponder before purchasing a dongle are: compatibility with your computer, the type of operating system, need for at least one USB port, what software to use, access to the Internet (for downloading software programs), soundcard requirement, user's level of computer literacy, what antenna to use for reception, coaxial cable for the antenna, and coax adapters for connecting the DVB-T dongle to an external antenna. Lastly and most importantly is choosing a reputable vendor since very little documentation exists for this adaptation of the dongle for radio reception.

My first dongle was purchased from Nooelec (www.nooelec.com) and my experience has been very positive as their customer service is superb and they supply detailed product specifications for most of their dongles. Keep in mind that this is not a "plug and play" endeavor so be prudent when buying, check out the customer feedback on the product and the seller, and see what the specifications of the dongle are prior to purchase.

When you've finally purchased your dongle it will include accessories such as a miniature magnetic/suction cup mount antenna for DAB

3. DVB-T Dongle along with typical accessories supplied by vendor.

4. Author's Procomm Spider broadband antenna covers 30 – 1200MHz.

radio, FM radio (64 – 108 MHz), and DVB-T television reception, a Quick Setup Guide CD, user manual, sometimes a short USB to USB cable, and possibly an infrared remote control. The CD contains instructions for using the dongle for DVB TV, FM and DAB radio reception along with the application software and required drivers. However, do not download those drivers as they are completely irrelevant for using the dongle as a broadband receiver. Later on in the article we'll talk about software, including the driver program necessary for the computer and dongle to communicate with each other. For our purposes the only useful item will be the DVB-T dongle.

The next item on your agenda should be choosing a receiving antenna as the supplied mini-antenna has very limited capture area and will not work optimally. In the world of radio the old adage "bigger and higher is better and outside is better" applies. That is, mount your antenna as high as possible, preferably outdoors, and the larger antenna the better. Antennas can be "homebrewed" (homemade) or purchased and a plethora of choices exist depending on one's budget, location, neighborhood restrictions, etc. An omni-directional broadband antenna would be a good first choice so again do some data mining on the Internet using search strings such as "scanner antenna" or "broadband antenna" and discover what is available. At my location I use a commercially available antenna purchased from Universal Radio Inc. (www.universal-radio.com), namely the Procomm Spider SP-800 (www.procommproducts.com) which covers 30 – 1200 MHz and costs $39.95 USD. For an antenna feed line use a good quality coaxial cable for broadband use such as low loss, double shielded 75 Ohm RG-6 which is readily available at most "big box" stores and is economically priced at about $20.00 USD per 100 foot roll. RG-6 coax usually comes supplied with male F type compression connectors on each end so you'll have to purchase the proper adapters to connect the feed line to the dongle and antenna. Remember to keep coaxial cable runs as short as possible to minimize loss.

Another consideration is that DVB-T dongles will have either a PAL (IEC 169-2) or MCX connector for attaching the antenna so you'll need to purchase an adapter connector such as a PAL-to-F adaptor or MCX-to-F adapter. These are readily available at a reasonable cost from websites such as Ebay (www.ebay.com), Amazon (www.amazon.com), or Nooelec (www.nooelec.com). The best approach is to purchase the correct adapter(s) when ordering your dongle to minimize additional delays in getting started.

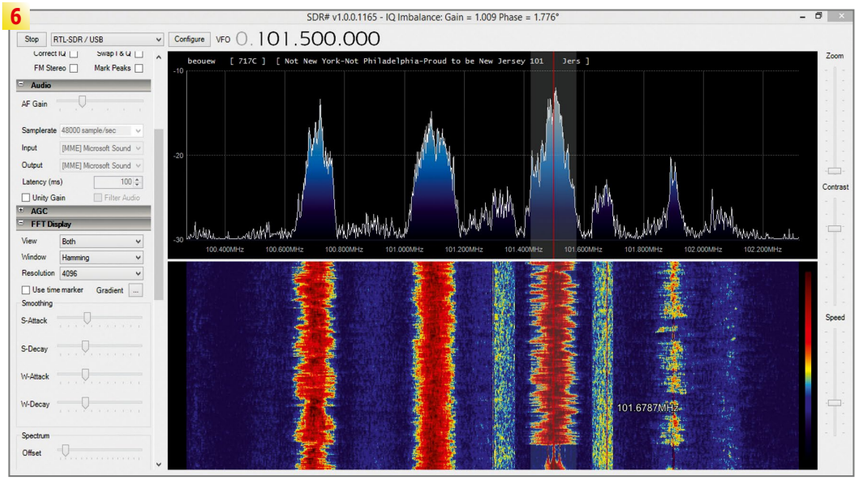
5. Examples of adapter connectors for external antennas.

6. SDR # dashboard of local New Jersey broadcaster 101.5. Notice RDS (Radio Data Service) info above the spectral display.

Software choice is the next major and challenging decision point as there are a number of types to choose from based on your computer's Operating System (OS). Some are PC based using Windows, others are Linux based, and some are for the MAC. The application software and drivers required to transform your dongle into a Software Defined Radio (SDR) receiver are easily obtainable from the Internet and a majority of them are free. Again, your OS will dictate what software you'll download. For this article I am using Windows 8 as this is the OS for my Dell Inspiron 15 laptop computer.

The two most common applications software are HDSDR (High Definition Software Defined Radio) and SDR# (a.k.a. SDR Sharp) and you can find information on their respective websites, www.hdsdr.de and www.sdrsharp.com. These sites offer no-cost downloads along with detailed installation instructions, so carefully read the specifications and recommendations carefully prior to downloading. Both of these excellent programs not only convert the dongle into a low cost SDR (Software Defined Radio) receiver but also come with a mind-boggling array of user options such as mode selection (AM, FM, SSB, etc.) RF/AF gain, AGC (Automatic Gain Control,) variable bandwidth filters, spectral analysis/waterfall display, infinite channel memory, variable squelch, signal strength (S meter), digital noise reduction, noise blanker and choices of different FFT (Fast Fourier Transform) displays. Note that there are some differences in user options between the two programs so do your homework and investigate all they have to offer and make an informed decision. Having extensive experience using both HDSDR and SDR# I can unequivocally state that these programs are all you need to pursue endless hours of radio listening entertainment consisting of FM broadcasts, police, fire, EMS (Emergency Medical Service), NOAA (National Oceanic and Atmospheric Administration) weather broadcasts, marine radio, aeronautical, ham radio, pagers, railroads, business band and utility radio transmissions.

In this article we'll not delve into the specifics of how to download the application software, but basically you'll first download the driver from the aforementioned websites, along with the software specific for the dongle radio and your computer's OS. Another excellent source of information on how to set up a dongle radio is YouTube (www.youtube.com) where you'll find countless how-to's from hobbyists around the world who have discovered innovative uses for this mini-receiver. Other websites specializing in this hobby are HamRadioScience (www.hamradioscience.com) and RTL-SDR.com (www.rtl-sdr.com). Also, searching the Internet using search strings such as "DVB-T dongle," "SDR dongle," or "RTL-SDR" will supply enough hits to keep one occupied until doomsday!



So, what can one hear and "see" when firing up the dongle radio along with HDSDR or SDR#? Well the fun certainly commences once you have your dongle running and antenna attached; you'll spend many hours surfing the ethers due to the prodigious width of the radio spectrum that's available to you and the numerous signals inhabiting the airwaves. You may initially suffer from option paralysis as to what to listen to first but my suggestion is to tune into the FM broadcast band initially, as these high powered 24/7 stations are the easiest to hear and known by many. Try "getting your feet wet" (as we Americans say) in this 20 MHz sliver of the spectrum (generally from 87.9 – 107.9 MHz depending on your location) and experiment using the various user options in HDS-

DR or SDR#. This is a great starting point for neophytes to become accustomed to and comfortable with the intricacies of software defined radio. Be sure to plug in headphones or ear buds and listen in as these SDR radios sound very similar to good quality FM receivers.

One of the powerful features of both SDR# and HDSDR is the RF (Radio Frequency) spectral display and waterfall. These visual parameters are of immense value to the radio hobbyist; for example the upper spectral display can be used to determine the bandwidth, signal strength, signal fade, waveform and distortion of a received signal. The lower or "waterfall" display is a time recording of the signal and an indicator of signal intensity as red indicates a very strong signal and white indicates a weak signal. Some of the SDR# user options are visible to the left such as, AF Gain (volume control), AGC, and slider bars to adjust the FFT. Slider bars on the right are to zoom in on a smaller portion of the spectrum, waterfall contrast, and speed of the spectral/waterfall display. Spend your first few hours with the dongle on the FM band and familiarize yourself with all the plentiful features

7. HDSDR dashboard of NJ 101.5 on the FM band. Other FM stations peaks are at 200 KHz intervals.

8. Two MHz scan of the aircraft band showing peaks at 134.2, 134.6 from pilot communications.

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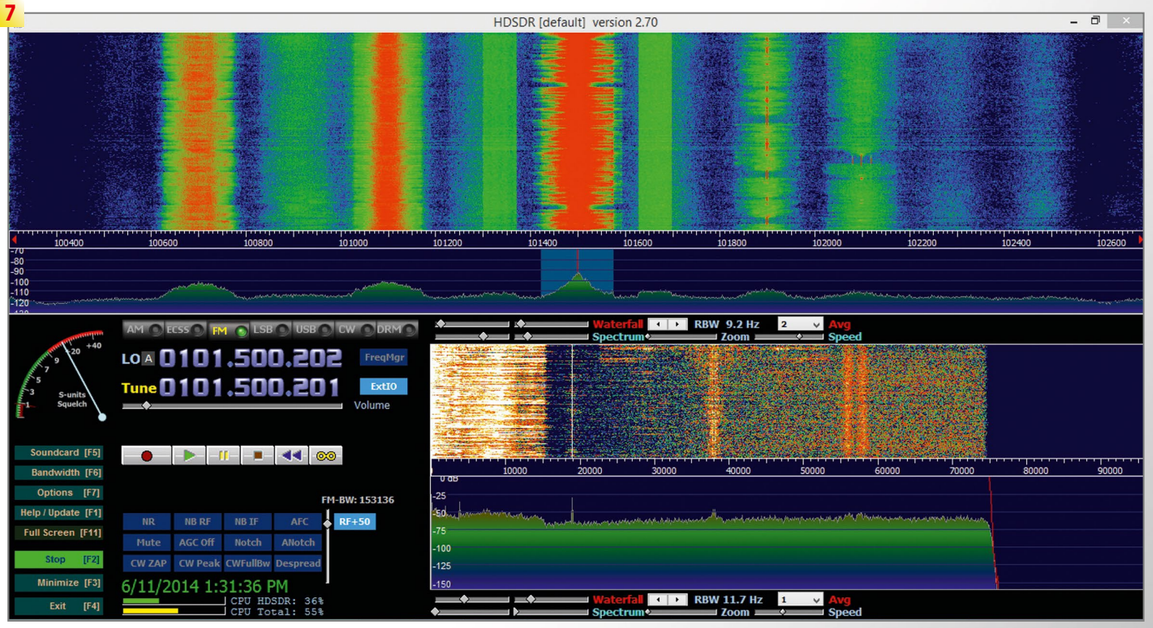

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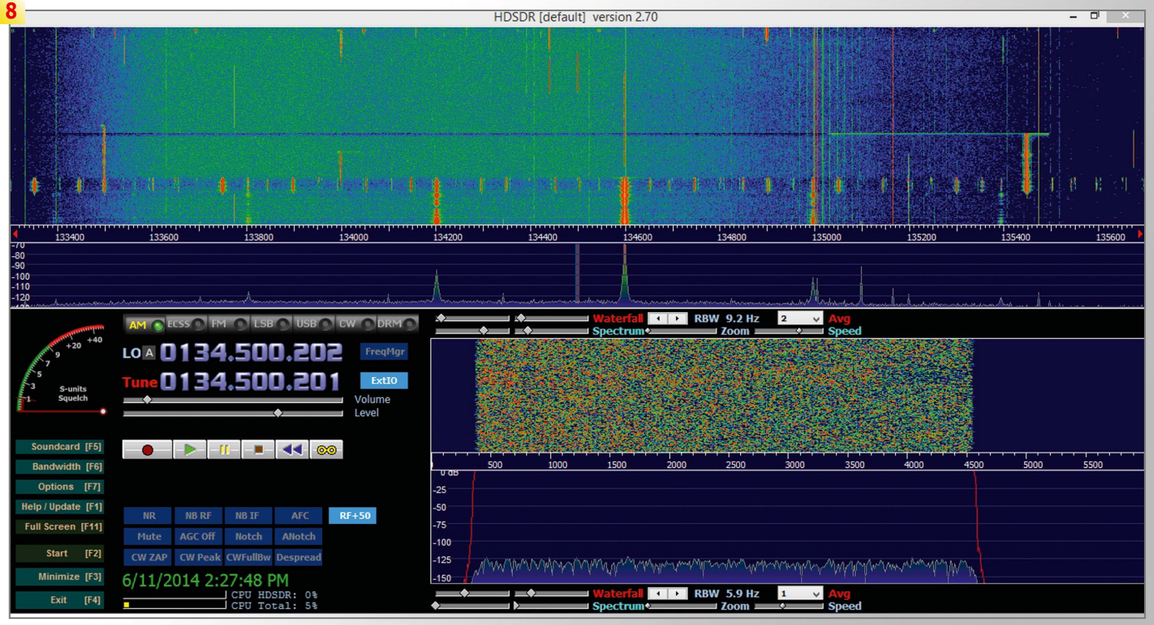
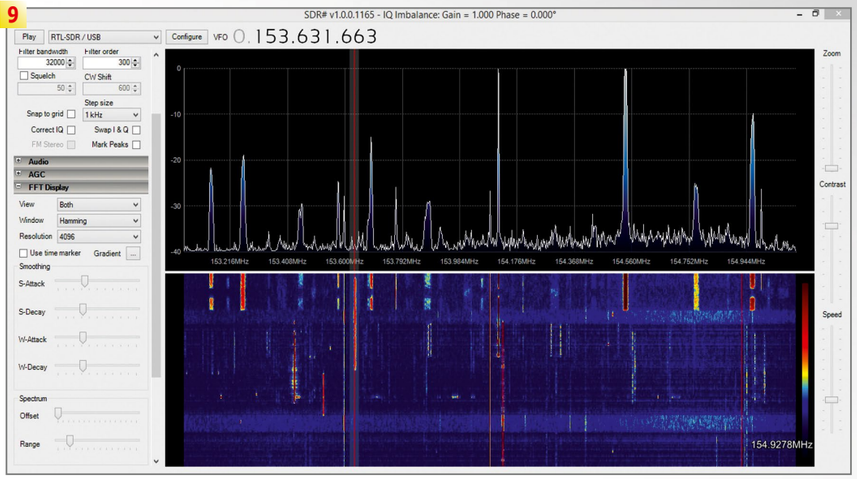


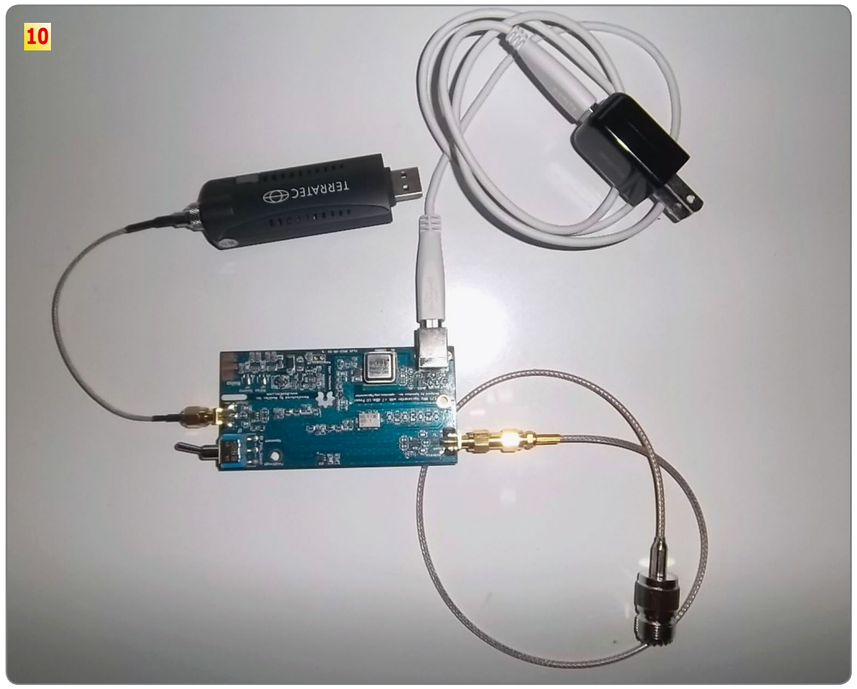
that the software provides.

HDSDR is another of the popular software application programs available from the Internet and presents quite a different appearing operating screen but has many commonalities with SDR# such mode (AM, FM, USB, LSB, CW etc.), bandwidth, volume, noise reduction, AFC, squelch level, noise blanker, soundcard selection, and sliders for adjusting the spectral/waterfall displays. One conspicuous difference is the large S (Signal Strength) meter which comes with a calibration protocol for those analytical types. Whether you choose SDR# or HDSDR is a personal preference but why not utilize both as I do? They are both excellent performers but you still may prefer one over the other. Note that both programs have a Frequency Manager option which allows the user to store an unlimited amount of memories and recording options for playback at a later date.

Once you've become comfortable using the DVB-T dongle on the FM broadcast band you can now navigate the other thousand or so megahertz of the VHF/UHF band to satisfy your curiosity. Perhaps the VHF aeronautical band is of interest to you so let's ride the magic carpet a few megahertz up to the 108 - 137 MHz portion of the radio spectrum and see what's happening in the skies above. Be sure to select the AM mode as all voice communications between pilots and ground stations communicate via Amplitude Modulation. Best time to listen to air traffic is during rush hour and the closer you are to a main air traffic route or airport the better. Aircraft communications are of very short duration with minimal words exchanged, so you have to be very quick and move the frequency cursor selector around the band quite frequently. Pilot and ground station traffic will be found in the 118 – 137 MHz portion of the band so keep that in mind. With experience you'll eventually find commonly-used frequencies where you can sit back and wait patiently for the next radio transmission from a pilot or air traffic control tower. An outside antenna mounted well above ground is almost mandatory to enjoy this portion of the band with any success.

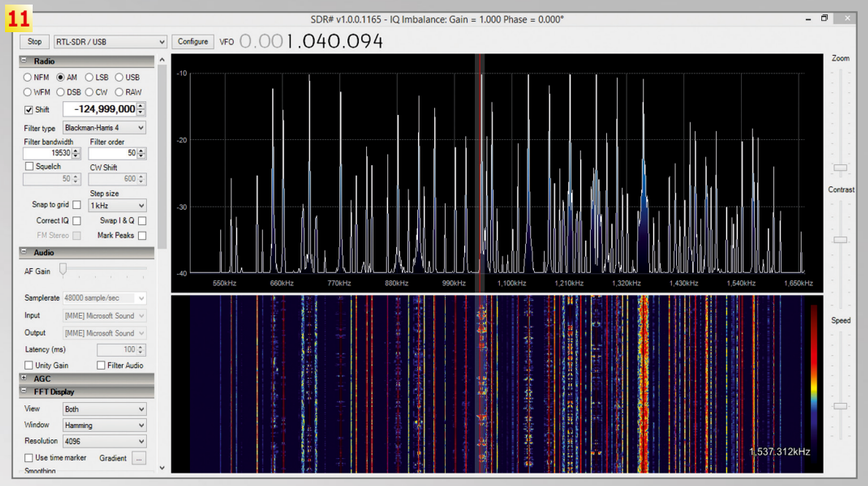
Global warming, whether man-made or not has resulted in an uptick of Mother Nature's wrath in all portions of the globe. Not a day goes by without media reports of some area of the world under siege from catastrophic meteorological, geological or oceanographic events. To stay informed, especially during emergencies such as fire, floods, mudslides, tornadoes, ice storms, tsunamis, earthquakes, and hurricanes the dongle radio is your pipeline to important information as it is happening. During emergencies the public service sector shifts into high gear, responding to flooded areas, downed power lines and trees, attending and rescuing

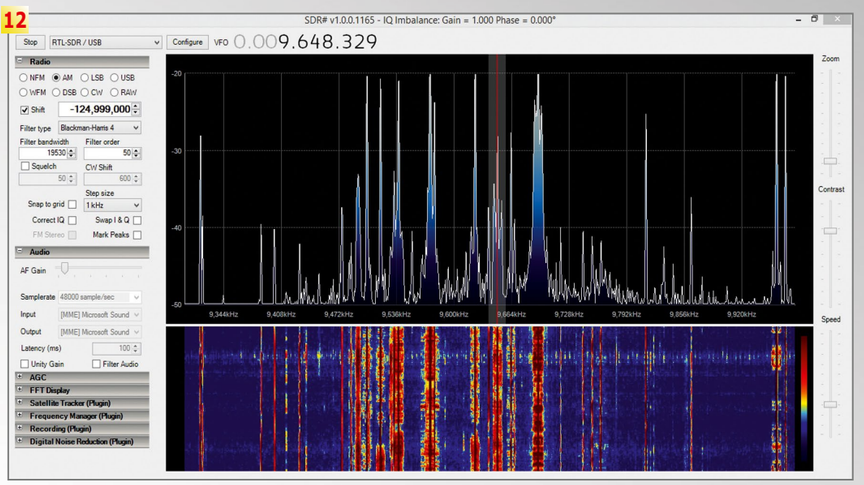




9. Activity abounds in the public service portion of the VHF band with signals from police, fire, emergency medical services, and pagers.

10. Adding a Ham It Up RF upconverter in line with dongle expands frequency range down to 150 KHz.





11. AM broadcast band, 540 – 1710 MHz, through the eyes of the dongle radio.

12. 31m shortwave band (9.4 – 9.9 MHz) is home to several shortwave broadcasters including Radio Romania International, Radio New Zealand International, Radio Habana Cuba, and Radio Japan.

the sick and injured, responding to accidents and traffic troubles along with an array of other catastrophes that plague neighborhoods when disasters strike. A wideband receiver such as a DVB-T dongle will allow one to monitor a very wide swath of frequencies used by first responders and will keep you informed with what is happening long before discovery by the news media.

If your thirst for adventure needs to be assuaged then adding a converter in tandem such as the Ham It Up RF upconverter (www.nooelec.com) will expand the frequency range of the dongle down to the LF (Low Frequency), MF (Medium Frequency), and HF (High Frequency) areas of the radio spectrum thus allowing you to listen to shortwave broadcasts, shortwave utility stations, the AM broadcast band, and the Longwave band. As a avid shortwave listener since the 1960's I purchased the Ham It Up upconverter from Nooelec.com with undue haste after my dongle arrived since my interests included reception of shortwave radio broadcasts, time signal stations such as WWV and CHU, RTTY (RadioTeleType), WEFAX (Weather Facsimile), DGPS (Differential Global Position System), NAVTEX (Navigational Telex), CW (Morse Code), ALE (Automatic Link Establishment), Sitor B (Simplex Teletype Over Radio Mode B), and many other non-voice digital modes that abound on shortwave.

Several versions of upconverters are on the market that will pair with the SDR dongle ranging in cost from $40.00 USD and up. Some, like the Ham It Up require a separate five volt power source, additional connectors, and of course another antenna designed for shortwave reception. The Ham It Up upconverter uses a 125 MHz crystal oscillator to shift the dongle's LO (Local Oscillator) up by 125 MHz. It is a very well-made, well-documented, and excellent product that comes at a very low price, $44.95 USD. Once you have your upconverter you'll have to erect an antenna such as simple outdoor 30 to 50 foot wire strung as high as possible. This antenna will suffice initially but again, there's a limitless supply of commercially available shortwave antennas on the market and many antenna designs available Do-It-Yourselfers on the Internet. For apartment dwellers and those with antenna restrictions all is not lost, as there are several manufacturers of indoor "active antennas." By "active" is meant that the antenna has built in circuitry to amplify received signals and attenuate unwanted signals. One such supplier if MFJ Enterprises Inc., (www.mfjenterprises.com), a long-time reputable manufacturer of an array of amateur radio and shortwave products. You can also check Universal Radio Inc., (www.universal-radio.com) for their selection of active indoor antennas. And happily, SDR# and HDSDR will work perfectly when using the dongle/converter combination.

Let's discuss a bit more about what's to be heard on shortwave using your dongle with an upconverter. The high frequency (HF) band by convention spans the range of 2 – 30 MHz and in this 28 MHz of spectrum you'll find foreign broadcast stations such as Radio Habana Cuba, BBC, WBCQ, VOA (Voice of America), Voice of Vietnam, Radio Japan, and Radio Romania to name a few. Stations broadcasting on HF use AM mode and are found in distinct, designated regions of the HF spectrum. These distinct regions are called "shortwave bands" and are classified according to wavelength such as the 60m (60 meter), 41m, 31m, 25m bands etc. In all, there are approximately a

dozen shortwave bands to choose from. If you are interested in listening to international shortwave broadcasts begin with the 31m band covering frequencies 9.400 – 9.900 MHz. The 31m band is one of the more heavily occupied bands where you'll find plenty of interesting listening 24/7 due to favorable ionospheric conditions affecting this slice of spectrum. Sadly, many old-time shortwave broadcasters such as Swiss Radio International, Radio Austria, and Radio Moscow have "gone dark" (ceased broadcasting) on shortwave due the advent of satellite and Internet radio, but plenty of entertainment from around the world still exists on shortwave, so tune in and listen.

In addition to international broadcasters, the HF spectrum is occupied by military, government, aeronautical, amateur radio, marine, weather, and other utility ("ute") communications using voice (Upper or Lower Side Band) and non-voice digital modes such as CW, RTTY, FAX, ALE, Sitor B, NAVTEX, HFDL, JT65, PSK31, and SELCAL to name a few. Interesting transmissions such as synoptic marine weather reports to mariners, QSOs (conversations) between ham operators using Morse code, PSK31, and teletype, facsimile weather maps of different regions of the world, infrared satellite images, and emergency/welfare messages from ships at sea are being transmitted around the clock. The good news is that the SDR dongle is sensitive, selective, and stable enough to allow decoding of many of these non-voice digital transmissions. This aspect of the radio listening hobby is referred to as HF Utility ("UTE") monitoring. If you are interested in these types of transmissions an excellent source of information is The Spectrum Monitor Magazine (www.thespectrummonitor.com), a monthly on-line magazine staffed by columnists with a wealth of experience in the radio listening hobby.

Use of digital mode decoding software will significantly enhance the overall experience with your SDR dongle as there are many exiting and informative transmissions being sent by commercial, military, and amateur radio entities. Two excellent programs worthy of consideration are fldigi (www.w1hkj.com) and MultiPSK (http://f6cte.free.fr/index) which feature decoding of many common digital modes including RTTY, FAX, CW, PSK 31, NAVTEX, Sitor B, etc. Two other digital modes used by commercial interests include SELCAL (Selective Calling) and ALE (Automatic Link Establishment). One word of advice though: before venturing into digital mode decoding software become thoroughly comfortable with using your SDR dongle. Take your time and remember that the learning curve will be very steep the first few weeks. If you belong to a radio club perhaps a member already has experience with an SDR dongle so tap into their knowledge and experience. If you are on the fast track then I suggest you check out YouTube as it contains a prodigious number of user videos by those already experienced in the hobby. Finally, remember that at a cost of $16.00 USD a dongle SDR will not perform on par with commercially available SDRs costing several hundred dollars. However, for its minimal cost you'll get a lot of "bang for your buck" as we Americans say.

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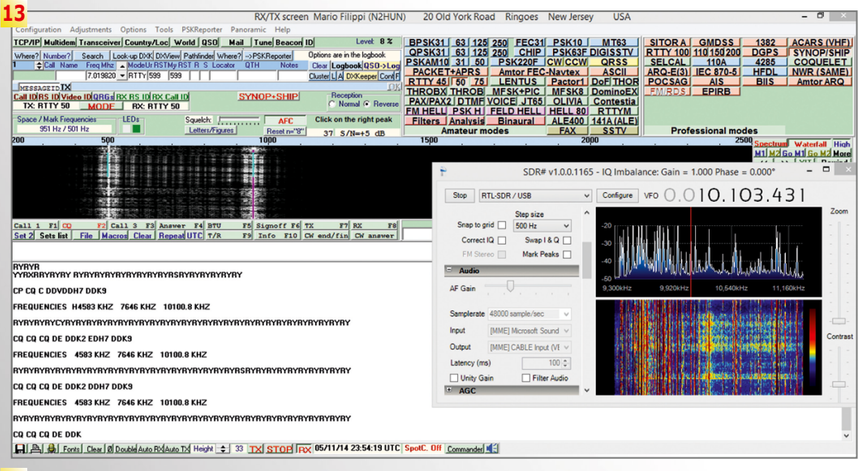
RX/TX screen Mario Filippi (N2HUN) 20 Old York Road Ringoes New Jersey USA
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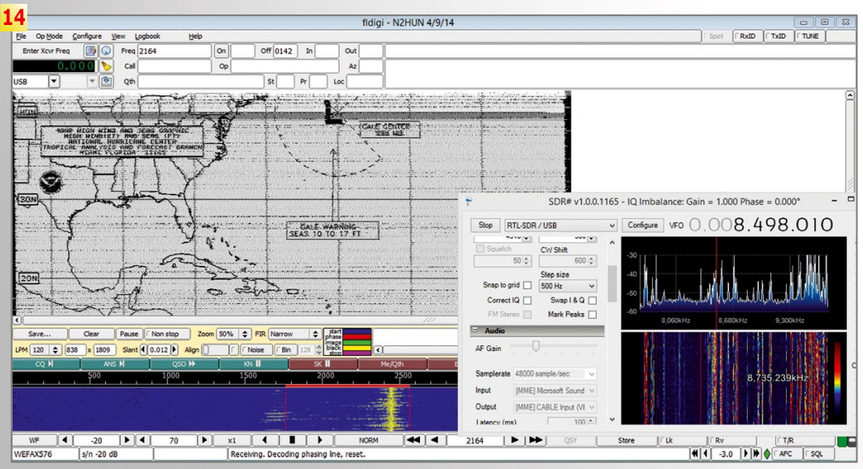
fldigi - N2HUN 4/9/14
SDR# v1.0.0.1165 - IQ Imbalance: Gain = 1.000 Phase = 0.000°
GALE WARNING
SEAS 10 TO 17 FT
Receiving. Decoding phasing line, reset.

13. RTTY (RadioTeleType) transmission from German station DDK 9 broadcasts marine weather for locations such as Western Europe. You'll need a good decoding program such as MultiPSK to decipher RTTY transmissions. SDR# is running in the foreground with MultiPSK in the background. The audio stream from SDR# is fed directly to MultiPSK.

14. Facsimile broadcast from US Coast Guard Station NMG, New Orleans, LA, with map of coastal US and Caribbean. Many stations service the marine community with facsimiles containing important meteorological information in the form of weather maps and satellite images. SDR# is running in the foreground with fldigi (decoding software) in the background.